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Information Sharing in Improving Supply Chain Performance

Bachelor's Thesis
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1. INTRODUCTION

The purpose of this Bachelor's thesis is to show, that there is value to be gained in sharing sensitive, intra-company data with key suppliers. The main source of this data are the ERP (Enterprise Resource Planning) systems used by companies. Information sharing is the foundation for supply chain integration, or extended enterprise, the opposite of a vertical integration. The goal of information sharing is to decrease supply chain costs, improve its performance and increase cooperation.

What makes this topic so interesting and important is the ever-complicating business environment. Throughout history, companies have sought and adapted to new ways of operating. Focus on core competencies and increasing global competition in raw materials, components and manufacturing has forced companies to do their absolute best in their own business area. Thus, it's no longer enough to produce low cost goods; they must be good as well. The rise of value chain thinking has highlighted the role of suppliers as important contributors in generating customer value. Today, many products consist of components made by several suppliers, and many manufactures are more like assemblers. Because of this, traditional brands are being challenged by unknown contenders, which produce as good products made from same components as the more expensive ones. Thus, manufacturers should cooperate and share information with their suppliers in order to find new ways to stay ahead of the competition. Suppliers also benefit due to increased predictability, for example.

This thesis aims to answer the question: is information sharing beneficial? Should companies send orders to their suppliers once every time period, or should they share their data with the suppliers and have varying delivery dates? The focus is on sales and stock data, since they're most widely available. This "simple" data is used to optimize stocks, orders and deliveries. Thus, the benefits of this kind of information sharing are limited to improving production and logistic processes, and cost reduction. Other uses of information sharing include using customer and product data for product development and marketing, for instance. Also, an emphasis is laid on ERP systems as enablers of information sharing. ERP systems have an important role in gathering information to be shared. Cloud based services are emerging, and the rationales for replacing old ERP systems with Internet based ones are also covered in this thesis. Different ventures and programs information sharing enables are also covered, VMI (Vendor Managed Inventory) for instance. The research methodology used was literature review.

Information sharing has two dimensions: strategic and operational. Programs, such as VMI, can be seen as strategic, since they change the way companies operate and require long-term planning and cooperation. The operational side is optimizing routine processes, such as deliveries and inventories, by sharing information with suppliers. With the help of information, suppliers are able to plan production better and thus can match demand more effectively, which reduces costs also for the sharing party. Information sharing requires absolute trust, but the potential gains for all parties are also significant. Typically, the fear of sensitive information exploitation is what prevents companies from sharing information, which can be countered by non-disclosure agreements, for instance. Another factor complicating information sharing is lack of IT capability or compatibility.

The findings of this thesis could be used in organizations which face high supply chain -related costs, especially backorder or inventory costs. The findings presented here provide support for increasing collaboration in supply chains, and some concrete ways of adding value to supply chains. The third chapter provides important aspects to keep in mind when acquiring information sharing -enabling ERP systems. The fourth chapter focuses on capturing the benefits of information sharing, supported by a case study. Next, an introduction to different concepts related to information sharing are covered.

2 CONCEPTS AND THEMES RELATED TO INFORMATION SHARING

2.1 SUPPLY CHAIN MANAGEMENT (SCM)

A supply chain is defined as a process to fulfill a customer's request. It consists of all the entities, i.e. firms, of the process, both upstream and downstream. A supply chain may be classified by its complexity: direct supply chain, extended supply chain or ultimate supply chain. The simplest one is the direct supply chain, consisting of three parties: supplier, buyer and customer. The extended supply chain also includes second-tier suppliers and customers. The most comprehensive definition is the ultimate supply chain. It contains all of the entities involved in the supply chain, even the financial providers and market research firms (Mentzer et al. 2001).

SCM is the management of materials and information flow of the entire supply chain (Constantinos, 1999). Usually SCM covers the complete supply chain, hence the term ultimate supply chain reflects best the complex functions involving multiple parties faced in SCM. SCM evolved from the field of logistics, when companies began to see potential in collaborating with their suppliers, especially due to total quality management. In practice, SCM can be joint product development, delivery scheduling and process optimization, with the goal to benefit all parties involved. Information sharing and collaboration allows the entire supply chain to work in a synchronized manner, as it was just one company (Tarn et al. 2003).

Supply chain management assumes customer orientation and collaboration from all members of a supply chain. It also requires dedication and long-lasting partnerships from the members of the supply chain, since SCM is a long process, extending beyond the cost perspective. Thus it’s not uncommon that supply chain partners form strategic alliances. Information sharing is an important part of SCM, and is seen as one of its seven activities (Mentzer et al. 2001).

Systems used in SCM attempt to generate benefits from four functional areas: materials management, supply chain performance management, collaborative fulfillment and supply chain event management (Koskela, 2016). Materials management is basically information sharing and planning, “right place, right time” -way of thinking. Supply chain performance management is the constant measurement and evaluation of day to day operations. Collaborative fulfillment means committing to agreed schedules, whilst taking into account the entire process of reaching that schedule, i.e. seeing the big picture and acknowledging one’s part in it. Supply chain event management is the monitoring of every stage of the supply chain in order to ensure things go as planned. Close monitoring enables companies to notice quickly is something is not working as intended and thus enables them to take appropriate measures to correct the anomaly.

2.2 Enterprise resource planning (ERP) systems

ERP systems are an important part of businesses today. ERPs are used to register daily activities and transactions from different systems automatically into one place in digital form. They collect data real-time from activities within a company, which can be used for decision making and forecasting, and depending on the system’s sophistication, even to schedule production automatically (Ragowsky & Somers 2002). The data is generally used by managers, especially in business intelligence. ERPs are acquired to gain benefits. These benefits range primarily from operational, e.g. cost and cycle time reduction and productivity increase, to managerial, e.g. better resource management and performance improvement. ERPs also have strategic, IT infrastructure and organizational benefits (Shari & Seddon 2000). In terms of this topic increased IT infrastructure capability is important. Notably, literature about ERP systems is usually about their benefits or implementation difficulties. Since ERPs collect the data that is used in information sharing, the problems related to ERP implementation and how to avoid them are covered in chapter three.

ERP systems evolved from material requirements planning (MRP) systems in the 1980s, when the development of information systems made it possible to measure not only material usage, but also costs, as well as other corporate functions such as human resources and project planning (Umble et al. 2003). The fundamental functions of ERPs are presented next along with a comparison with SCM systems.

2.3 Comparison between SCM and ERP systems

First SCM software were sold separately from ERPs, and developed by different companies. Originally ERP systems were designed to operate in one company, and information sharing wasn't taken into account. SCM software essentially gathered some of the same data as the ERP system, and then shared it with compatible systems within the supply chain. First ERP systems had limited processing power, and couldn't record data needed in SCM genuinely real-time, and thus separate systems were needed. Eventually, ERPs improved enough to collect real-time data and had support for information sharing (Tarn et al. 2003).

	SCM systems	ERP systems
Objective	Integrating and optimizing internal business processes of a single organization as well as the interaction of the organization with its business partners across the entire supply chain	Integrating and optimizing internal business processes within the boundary of a single organization
Focus	Optimizing information flow, physical distribution flow, and cash flow over the entire supply chain	Optimizing information flow and physical distribution flow within a single organization
Goal	Constraint-based tool providing reasonable and feasible business plans based on the availability of the required key resources	Non-constraint-based tools providing business plans without the consideration of the availability of key resources
Function	Manufacturing management, inventory management, logistics management, and supply-chain planning	Manufacturing management, financial management, and human resource management

Table 1: SCM and ERP systems comparison (Tarn et al. 2003)

Table 1 summarizes the fundamental differences and similarities between SCM and ERP systems, which were covered in subtitles 2.1 and 2.2. Most notably, the focus of SCM systems is external and ERP's is internal. SCM systems also concentrate on managing the material flow of the entire supply chain, within constraints. Even though ERP systems have evolved, even today their main focus is still on collecting data from internal business processes. Thus, they collect data from more sources than required for SCM and information sharing. The scope of SCM systems covers the entire supply chain, ranging far from the company. SCM systems provide tools for visibility, planning and cooperation beyond an enterprise (Bose et al. 2008). Both systems have their benefits, but combining them can yield higher business value. Yet still, the benefits only emerge if data can be used appropriately or transformed into information.

2.3.1 Case: ERP and SCM integration

Neway is a Chinese-American joint venture company manufacturing valves, with a revenue of about $50 million in 2004. It set out to implement an e-SCM system since it had trouble with proper inventory rotation and keeping inventory up to date, since the inventory levels were updated into the ERP system manually, despite having over 20000 stock keeping units (SKU) (Bose et al. 2008).

The e-SCM system was to streamline inventory operations and enable interaction with suppliers and customers. With the system came handheld devices, which could be used to scan SKUs and guide workers. Scanning SKUs and determining where they should be placed ensured that the inventory level was up to date in the ERP system and that inventory was being rotated efficiently. Hence, the e-

SCM system improved internal processes a lot. It helped Neway reduce inventories, increase on-time deliveries and collaborate with suppliers and customers, in other words, engage in SCM.

Operational measures	Pre-implementation	Post-implementation
Outbound order fulfillment		
Commitment to fulfillment percentage (%)	80	98
Average lead time (min)	45	30
On-time delivery percentage (%)	80	95
Inventory		
Average safety stock period (days)	40	25
Inventory accuracy (%)	85	99
Average monthly purchase frequency	50	10

Table 2: Results of e-SCM and ERP integration at Neway (Bose et al. 2008)

As the results seen in Table 2 suggest, implementing the system was beneficial. The budget for the project was $92000, while the 15-day reduction in average inventory resulted in annual savings of approximately one million dollars. Also, the increased service level decreased the cost of lost sales by about $20000. Thus, the project was extremely profitable, with most of the benefits being due to the more efficient on-time inventory system. Neway also needed to be able to interact with customers e.g. about product specifications, shipping and ordering. Also, in order to respond to customers' wishes, it needed to interact with its suppliers as well. The e-SCM system provided a platform for this kind of information sharing (Bose et al. 2008).

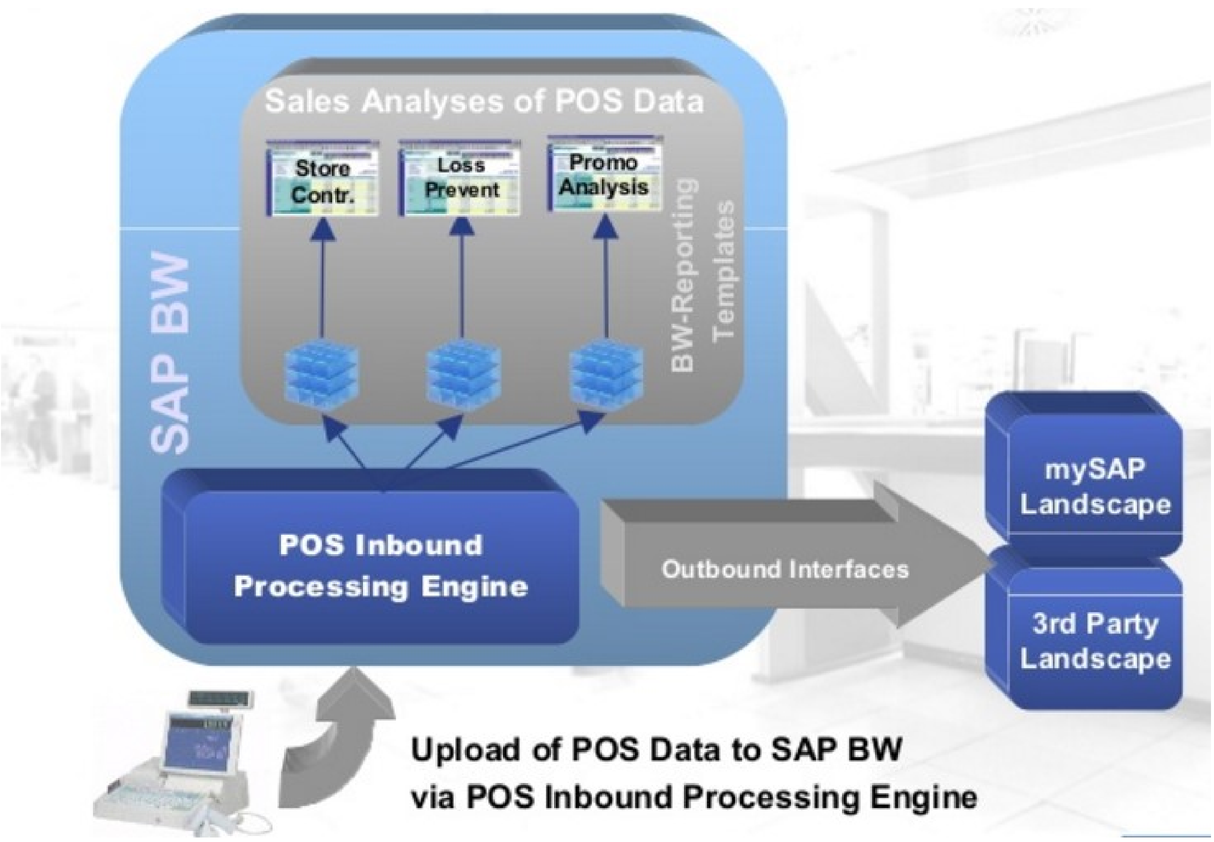
The Neway-case shows that having an ERP system doesn't necessarily make a company efficient. It also presents the dependency between ERP and SCM system, and how they can be combined to gain added value. Neway also found new value by creating an information sharing platform between its suppliers and customers, showing that supply chain cooperation is beneficial.

2.4 Introduction to information sharing

Information sharing is a basis for SCM (Mentzer et al. 2001). Also, the advanced practices of SCM such as just in time and continuous replenishment programs wouldn't be possible without information sharing. ERPs are usually the systems which record the information which is then shared in the supply chain. The systems need to provide real-time, relevant and accurate information in order to take information sharing's benefits to the fullest. Standards such as EDI (electronic data interchange) have been developed to ensure compatibility among information sharing software.

Active cooperation and interaction with suppliers are the general paradigms of SCM, and those activities are conducted daily by sharing information. There are many types of data which can be shared, and the companies involved in information sharing should asses what kind of data and to what extent they share information. According to Kelle and Akbulut (2005), there are at least four groups of data that could be shared: operations information, planning information, customer requirement information and financial information. Byrne and Heavey (2006) also presented five shareable types of information based on an article by Lee et al. (2000). These are inventory level/position, sales data/demand information, order status for tracking/tracing, sales forecast and production/delivery schedule. These types are primarily used for the operational side of information sharing. Depending on the industry, companies make decisions about what information is shared, typically at least sales- and inventory data. User data, for instance, can also be collected and shared for various purposes, but the focus of this thesis is on “traditional”, or operational, information sharing. As a limitation, it has to be noted that benefits presented in this thesis may not apply to all companies or industries.

This chapter introduced the concepts of SCM, ERPs and information sharing. They’re all bundled together, with information sharing functioning as a link between ERPs and SCM. ERPs produce the information which is shared with supply chain partners in an attempt to increase supply chain performance. The benefits of information sharing are covered in more detail in chapter four. The next chapter covers difficulties and success factors of ERP implementation, as well as new solutions which are replacing legacy ones. Due to the importance of ERP data for information sharing, a more detailed glimpse into implementation of ERPs is provided.



Picture 1: Point of sale data usage in a SAP ERP

Picture 1 above demonstrates how POS data collected by ERPs can be used within and outside the company. As seen from the picture, the focus is on analyzing sales data for intra-company decisions and to monitor store contribution, for instance. But the same data can be shared with suppliers, which may lead to better service level and reduced inventories. This clarifies the role of ERPs as enablers of information sharing but also, how "easy" information sharing can be at the very simplest level.

In this chapter, the costs and hurdles of ERP implementation are covered, and an example of a troublesome implementation is presented. Lastly, cloud based SaaS systems and their benefits over legacy systems are covered.

3.1 COST OF LEGACY ERP SYSTEMS

Implementation of traditional ERP packages may incur investments of an average of 5,6 per cent of annual revenues, and even 50 % for smaller companies (Mabert et al. 2000). But the costs aren't the only factor that might induce problems for companies. Umble and others (2003) analyzed survey results comprising of 63 companies by Meta Group. The average implementation time of an ERP system was 23 months, and the average cost was $10,6 million in the publication year 2003. Also, in the same article there are mentions of researches showing that over 90 % of ERP projects exceed budgets and schedules, and that after a six-year period, ROI loss of ERP projects was $1,5 million. An example of a difficult ERP project is presented in chapter 3.3. Taking into account the lifespan and benefits of an ERP system the six-year timeframe may be too short, though. Cost savings and productivity increases related to process reengineering and new ways of operating may be difficult to measure and target. New SaaS based systems, or programs, help reduce implementation costs and thus make ERPs a more viable option in general in contrast to multiple individual systems.

When it comes to costs, the ones most overlooked are related to training (Tarn et al. 2002). This is partly due to the fact that some costs caused by lack of training are indirect. Low productivity, inefficient and slow procedures and confusion regarding the new ERP system are examples of indirect, training related costs. Some studies have shown that investing 10-15 per cent of the ERP budget to training will increase the chances of successful implementation to 80 % (Umble et al. 2003). Obviously, this cannot apply to every organization out there but it gives insight.

3.2 ERP IMPLEMENTATION CHALLENGES

Barker and Frolick (2003) argue, that most pitfalls related to ERPs are caused by the implementing organization itself. Typically, there are three major risks to complicate ERP introduction and use. Usually most difficulties are related to personnel resistance, (over-budget) costs and lack of knowhow. Also, consulting is often one unacknowledged source of cost. As many as 150 consultants can be needed for successful implementation alongside with about 30 per cent of the implementation budget going to consulting costs (Bingi et al. 1999).

Change management and justification are extremely important when introducing an ERP for the first time. ERPs typically change the way a company operates, and may lead to reductions in personnel and redesigned job descriptions. This may initiate resistance among employees and hence it’s important to justify all the upcoming changes and thus receive adequate support for the project. Unmotivated employees are less likely to use the new system and learn how to use it, which may cause decreases in productivity and increase costs. Employee education is as important, otherwise the system is not operated properly (Bingi et al. 1999). Without people using the ERP to its fullest capacities, the company has just wasted money buying an expensive software package (Barker & Frolick, 2003).

During the implementation, data accuracy must be ensured. ERP’s are comprehensive systems, and one error may be multiplied several times. Ensuring data accuracy and absolute functionality in all functions explains why ERP projects are slow. Key performance indicators should be established throughout the implementation and operating phases. For instance, in the first stages of adopting an ERP productivity may decrease, due to confusion regarding the new system. KPI’s should be set to monitor whether these decreases are permanent. In addition to monitoring, companies should come up with ways to address arising issues.

3.3 ERP IMPLEMENTATION PREPARATION

The decision and planning processes for obtaining an ERP are strictly managerial tasks characterized by rational arguments and calculations, but the ERP system is operated by people and thus selling the software to employees is important (Barker & Frolick 2003). ERPs aren't just software; they affect how a company conducts itself and can't be managed as regular software projects because of that. Typically ERP systems are modular, and can be implemented in several phases. One phase may be company-wide, or limited to a certain, e.g. geographical, area. Experimenting in a smaller scale enables organizations to spot failures and malfunctions, and fix them before applying the system to the entire enterprise. Also, test runs with the new system can be executed alongside with old systems to find any problems (Bingi et al. 1999). When implementing the first ERP system, the workload is massive. Thus, it is likely that it will end up late and over-budget. Despite extensive preparations, launching in one area and training ERP implementation can go wrong, as in the case of Onninen, which is described in the next paragraph.

ERPs are the single most important information systems for information sharing (Kelle & Akbulut 2005). They are also extremely important for companies, in terms of day to day operations, strategic planning and in assembling figures for financial statements, for instance. Updating or replacing these massive systems can be very difficult despite extensive forward planning. Onninen, A Finnish service company operating in many European countries, set out to implement a new ERP system by Oracle in 2003, to enable flexible cooperation with suppliers and customers, inter alia. Despite help of consultants, phased implementation and careful planning the project was a failure, and in 2007 Onninen decided to change to a SAP system. Only in 2013 the system was running as expected, and in 2011 the company had its worst financial year ever, mostly because the ERP didn't run as expected, which caused employees to divert from value adding activities (Teittinen 2017). This case proves that ERP implementation can be a major challenge, and should not be belittled.

3.4 SAAS SYSTEMS

SaaS (Software as a Service), as defined by Sun et al. (2007), "- is a software delivery model, which provides customers access to business functionality remotely (usually over the Internet) as a service. The customer does not specially purchase a software license. The cost of the infrastructure, the right to use the software, and all hosting, maintenance and support services are all bundled into a single monthly or per-use charging."

SaaS systems represent the future of software, and they are replacing legacy software packages due their flexibility and lower costs. Since they're subscription-based, it's very easy to start and quit using SaaS software. Also, since there are no high software-related upfront costs, changing software providers is simpler. Similarly to many other industries, subscription based solutions are changing the software market too, and Gartner is expecting the SaaS market to double from 2014 to 2019.

There are several advantages and benefits to using SaaS instead of legacy software. Low initial -, subscription-, license- and upgrade costs, no need to install software, constant access and updates with only Internet connection required are among these. Costs are low mainly due to standardization (Mäkelä et al. 2010). Also, TCO (total cost of ownership) costs are low due to lack of investments to servers and databases (Torbacki 2008). In addition, all functions of the software are also available at all times. Even if a customer hasn't paid for a certain function, it can be taken to use whenever. SaaS systems are thus much more flexible than their traditional counterparts, even in ERPs. However, legacy software providers have introduced SaaS ERPs themselves too, Oracle NetSuite for example. Thus, the nature of competition is moving from software packages to services, and the traditional big players are still in the game.

Figures by Torbacki (2008)

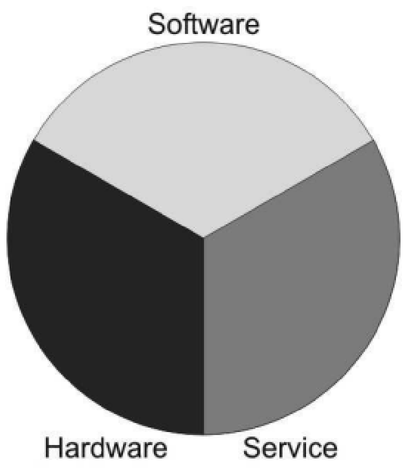


Fig. 1 Cost structure of traditional ERP

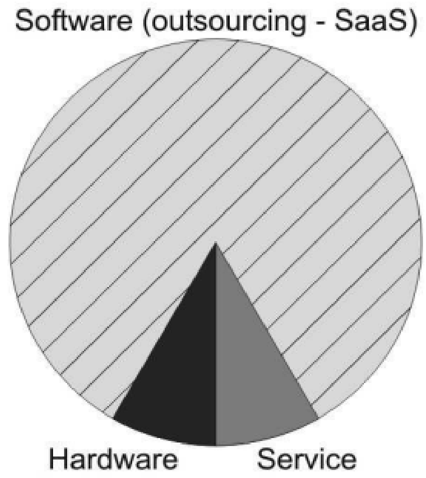


Fig. 2 Cost structure of SaaS ERP

As seen from Figures 1 and 2, the cost structures of traditional software packages and SaaS solutions are very different. One important point isn't visible from the figures: the overall costs of a SaaS ERP are lower than the ones of an equivalent legacy system, making ERPs acquirable by smaller companies. The cost structure of SaaS ERPs show, that most of the system's costs are for the software. Thus costs are more predictable, since major hardware upgrades aren't necessary, and service can be conducted over-the-air. Also, servers and other functions which keep the system running are outsourced, and the customer can simply focus on using the system.

SaaS ERP systems have many benefits over traditional ones, and that is why companies are replacing old ones with new SaaS systems. Lower costs and the "ready to use" nature of SaaS systems are major reasons for this. Still, ERP implementation is a massive project and companies should be aware of common pitfalls and ways to avoid them, even when implementing a SaaS ERP. Even though many difficulties related to ERPs were presented in this chapter, it should be kept in mind that ERPs are extremely useful systems, which help companies increase productivity, decrease costs and collect necessary information about the company and its processes. Digitalization and Internet of Things provide features that can be added to ERPs too, further making operations smoother. ERPs are the sources of data that is used in information sharing, the benefits of which will be covered next.

4 SEEKING VALUE BY SHARING INFORMATION IN THE SUPPLY CHAIN

4.1 WHY INFORMATION SHARING?

Complex supply chains have resulted in lengthy lead times. Lead times grow longer the more complex the chain is, since products are processed in and transported to many different sites. Companies ensure service levels with high safety stocks, decreasing the gains of outsourcing. Therefore, supply chain management and information sharing, e.g. sales data, are important today. Collaboration with suppliers can help reduce lead times, inventories and costs.

The need for information sharing in the supply chain comes from specialization, globalization and lean philosophy. As opposed to being vertically integrated, companies are specializing in their core competencies and thus produce only what they think they're best at. Thus, supply chains have grown longer and more complex, leaving companies depended on multiple suppliers. For instance, car manufacturers hardly make anything themselves, they just assemble the cars. In the car industry, suppliers account for 82% of a car's value added in 2015 (Statista 2015). Manufacturers use outsourced parts rather than making them themselves to reduce costs, the amount of invested capital and to spread and mitigate risks (Meyer, 2005). Due to dependence, it is also vital to maintain good relations with key suppliers. For example, Volkswagen was depended on one transmission component supplier which wasn't happy with the group's dictation policy, and stopped deliveries, resulting in production halts in fall of 2016 at six of Volkswagen's plants.

Enabled by globalization, companies often source products from cost-effective countries, and specialized firms are born in those countries, increasing efficiency (Ferdows 1997). Even though Porter's two generic competitive strategies are cost leadership and differentiation, many companies have found themselves doing both. Outsourcing is typically an easy way to reduce component costs. Besides lower costs, outsourcing is sometimes used to improve flexibility, reliability and product quality, two latter of which are important parts of lean. Lean philosophy has heavily affected the way companies operate today. Customer perspective, value adding activities, attention to stocks and streamlining of processes are some main principles of lean. When firms lay emphasis on what they do best, they maximize the value of products and minimize the costs. Usually, the reduction of costs is achieved by outsourcing and process reengineering. Holding and managing inventory is also seen as a non-value adding activity in many theories, and information sharing helps companies at least reduce inventory costs.

An interesting topic related to outsourcing is optimum firm size. According to this theory, the size of a firm is determined by make-or-buy -decisions. Generally, the smaller a company is, the more sense it would make for it to outsource, due to its lack of returns to scale. Larger companies should thus produce everything themselves, but the more the company produces itself, the larger it becomes vertically. At some point the company becomes so big and bureaucratic that outsourcing becomes economically profitable. According to the theory, no company can manufacture everything itself, in terms of efficiency, hence outsourcing is sensible. There's not much literature about this theory, but Canbäck's (2002) doctoral thesis proved that bureaucratic limits affect firm size. Outsourcing complicates the supply chain, increasing the need to share and receive accurate and timely information to prevent shortages and to monitor supply chain functionality.

The rationale for information sharing and supply chain integration is derived from the traditional nature of supplier-buyer relationships. The buyer wants to purchase a small amount at a time, but the supplier wants to deliver as much as possible at one time. Both want to minimize stocks, the supplier would like to make-to-order and prefers large orders to benefit from returns to scale, while the buyer wants to ensure its service level whilst minimizing inventory holding costs by small, frequent deliveries. This fundamental contradiction leads to compromises, causing losses to both parties. It can be difficult to estimate achievable savings by sharing information universally, since supply chains and industries vary so much. A JIT cooperation policy can lead to savings of approximately 10-20 per cent (Kelle & Akbulut 2005). In addition, supply chain integration and information sharing enable decisions based on all of the information in the supply chain.

In the next subchapters, the situations in which information sharing is most beneficial is covered and different models of information sharing are presented, followed by the known benefits of information sharing: reduction of demand variation in a supply chain, decrease of supply chain costs and increase of supply chain performance. Then, the division of benefits is reviewed, followed by different operating models which are enabled by information sharing, which can result in significant performance improvements.

4.1.1 When is information sharing most beneficial?

According to Lee et al. (2000), information sharing is most beneficial when lead times are long, demand variation is high and demand has a high autocorrelation coefficient. Longer lead times mean that once an order has been made, the supplier must get it right in the first attempt, since if it fails to deliver as agreed, backorders become very expensive. Demand variation naturally causes difficulties to suppliers, if they don't have access to real-time data. Buffer stocks are typically used to counter demand variation, but this increases inventory holding costs. High autocorrelation coefficients suggest, that future demand is very likely to be highly dependent on historical sales.

A crucial factor affecting the utility of information sharing is forecasting. It is often impossible to satisfy demand based solely on actual data, thus forecasts are required. But the benefit of forecasting is partly dependent on the extent of information sharing. A retailer may have very accurate forecasts, but they have no value if the supplier is unable to fulfill the order. This may be due to limited capacity or maintenance, for instance. Thus, it would be beneficial for the retailer to share its POS data and forecasts with the supplier in order to ensure OTIF (On-Time In-Full) deliveries. This works both ways: information sharing isn't useful without proper forecasts (Boone & Ganeshan 2008). In a study by Byrne and Heavey (2006), using the correct forecasting method alone resulted in supply chain cost savings of 0,3% to 2,9%, depending on product and capacity at hand.

4.2 INFORMATION SHARING MODELS

Lee and Whang (2000) present three different ways of information sharing: information transfer model, third party model and information hub model. In the information transfer model, the buyer simply provides the necessary information to the supplier, usually through electronic data interchange (EDI), which is standardized and can be used as a tool for information sharing. Internet based services are also becoming widely used today. The information shared may contain forecasts alongside with point of sale data and inventory levels, depending on the degree of collaboration and need for information. The third party model includes a third player, which hosts a database containing the shared information. This model may include logistics- and transactional services. Transactional services can include a centralized ordering system, in which the third party takes orders and then delivers them to suppliers. The information hub model is like the third party one, expect that a machine manages the information. Only one well-known information hub service has been launched, a joint venture between Intel and SAP called Pandesic, which was shut down only a few years after launch. Today, SaaS services offering similar features can be seen as information hubs, as described by Lee and Whang, but they weren't built for that purpose only. This thesis will not emphasize on which model should be used, or what information should be shared since there are no universal answers. Organizations should make the decisions based on their own needs.

4.3 REDUCING THE DEMAND VARIATION: THE BULLWHIP EFFECT

A phenomenon usually related to complex supply chains is called the bullwhip effect, and information sharing is its direct counter (Claassen et al. 2008). The more complex, i.e. longer, the supply chain is; the stronger the effect. The bullwhip effect is defined as the amplification of demand variation along a supply chain. This demand variation causes buyers to order variable quantities from suppliers. The supplier itself then orders materials from its supplier to fulfill the order. Usually the orders aren't the exact same size, because suppliers are trying to adapt to the demand. If the order is larger than the previous one, the supplier might order a larger quantity itself to prepare for an even larger order in the next period. Supply chain members are thus constantly trying to balance between sufficient service level and cost effective inventory. Low level of stock is cheap to keep, but very vulnerable to sudden increases in demand. Too large inventories, however, have several drawbacks, such as increased invested capital, risk of obsolescence and spoilage and need of space (Lee et al. 2000).

Unexpectedly large orders may cause stock-outs, resulting in “panic orders” which are scaled to satisfy current, but also future demand. If the demand spike was just one-off, the supplier’s inventory probably grows too much. As a result, the demand increase resulted in backorders, increased inventory costs and dissatisfaction. The effects will then proceed to multiply in all echelons of the supply chain (Boone & Ganeshan 2008). The demand increase doesn’t even need to come out of the blue. Even relatively small variations in downstream order quantities may have big effects further up the supply chain. The further the supplier is from the end customer, the bigger the bullwhip effect (Yao et al. 2007).

By sharing real-time and accurate information in the supply chain, e.g. point-of-sale data, suppliers are aware of the actual need of goods. They are able to monitor the development of sales and spot possible trends before supplying, giving them time to adapt and plan production. This helps them order accordingly from their suppliers, reducing the risk of costs incurring due to the bullwhip effect (Yao et al. 2007). Information sharing also enables decisions to be justified with all the supply chain’s information. It should be kept in mind that point-of-sale (POS) data should be used to tighten a forecast, and not as a basis for an order since the information typically arrives too late. Centralized forecasting may also be used, in which a company close to the customer creates a forecast which is visible to supply chain members, and hence a possible forecast error doesn’t multiply at each echelon (Boone & Ganeshan 2008).

Figure 3 clarifies the bullwhip effect. The retailer tries to adapt to customer demand constantly, but its order quantity is always different from that of the customer, since it tries to optimize its inventory. Order quantity continues to vary among upstream suppliers, who make their own predictions based on their customer’s demand, increasing the forecast error, resulting in inaccurate orders which cause swings in inventory quantities and costs. Increased end customer demand causes excessively large orders and inventories, and decreased customer demand leads to insufficient orders and even stock-outs. As seen from the figure, the effect grows stronger the further the echelon is from the end user. Since stock-out costs are typically larger than those due to holding extra inventory, companies tend to order more than they anticipate demand to be.

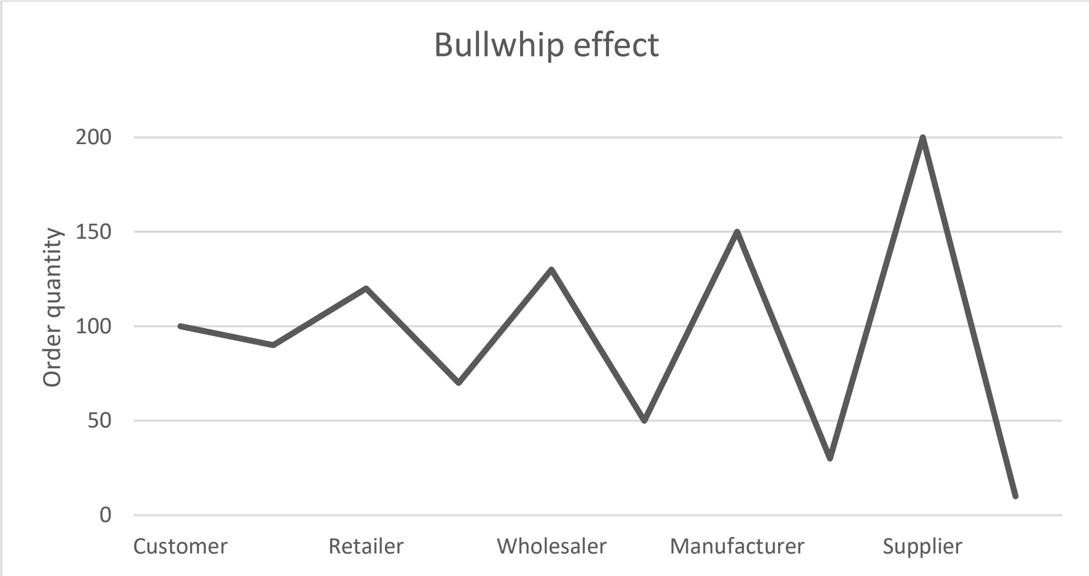


Figure 3: Bullwhip effect

Even though it has been shown that information sharing is a known cure for the bullwhip effect (Yao et al. 2007), it does not completely eliminate it. This is because even when every echelon of the supply chain receives an accurate order, based on a forecast tightened with actual data, they are likely to generate their own forecast. Every forecast is inaccurate to some extent, and by going further upstream, the error is repeated which leads to more variation and the bullwhip effect. But with the help of information sharing and accurate forecasts, these recurring forecast errors can be limited to being additive functions. On the other hand, without information sharing the demand variation is multiplied at every echelon. Hence centralized demand information helps reduce the bullwhip effect substantially, but does not eliminate it (Chen et al. 2000).

4.4 Decreasing costs and improving performance: A case study

The case study "The impact of information sharing and forecasting in capacitated industrial supply chains: A case study" by Byrne and Heavey (2006), studied the effects of information sharing in an industrial supply chain consisting of SMEs (Small to Medium Enterprise). The firm studied is called Company X, and it operates a multi-echelon supply chain, with several raw material suppliers. The company produces 16 different product classes which are delivered to eight distributors. The demand forecast methods it uses are SMA (simple moving average) and DES (double exponential smoothing). Some studies have shown that the SMA method generally works well with simple supply chain structures (Zhao 2002). Overall supply chain costs and service level were especially of interest in this study. The supply chain costs included processing, setup, inventory and backorder costs for Company X, and transport, inventory and backorder costs for the distributors. Average stock levels were also included.

In the study Byrne and Heavey discovered, that CT (capacity tightness), or capacity utilization, has a significant impact on information sharing efficiency. When operating near full capacity, the benefits of information sharing were at the highest levels, which is logical since when operating near maximum capacity, production planning becomes important. They measured supply chain costs and performance in the study, with 18 different scenarios. These scenarios were calculated with CT values of 1,05 (high capacity), 1,18 and 1,33 (low capacity), representing resource utilization of 95%, 85% and 75% respectively. They also studied the effect of forecasting methods, and the benchmark for the SMA and DES forecasts was actual data. So, in the "ACT" method, next period's actual demand was used to plan production. Supply chain costs were calculated for both the distributor and company in euros, and performance as "- the percentage of finished stock orders that are OTIF…" (Byrne & Heavey 2006).

The information sharing aspect was taken into consideration with two parameters, "INFO" and "NO INFO". NO INFO means that distributors send orders to Company X's finished stock personnel, who then review whether there's enough inventory to fulfill the order and proceed to production planning from there. The process is very reactive. In the case of INFO, distributors share their requirements continuously with Company X's APS (advanced planning and scheduling) system, which optimizes production. Thus, there are three variables: forecasting method, capacity tightness and information sharing. In the table below are the overall supply chain costs when operating at the lowest and highest capacities. The ACT parameter represents perfect information, and how the company would do in an ideal situation.

Forecast Method	CT	Type	Overall Supply Chain Costs (€)
ACT	1,05	NO INFO	104 122 265
SMA	1,05	NO INFO	121 233 333
DES	1,05	NO INFO	123 620 430
ACT	1,05	INFO	106 510 087
SMA	1,05	INFO	113 533 255
DES	1,05	INFO	115 084 054
ACT	1,33	NO INFO	62 425 765
SMA	1,33	NO INFO	67 839 461
DES	1,33	NO INFO	66 428 797
ACT	1,33	INFO	59 766 192
SMA	1,33	INFO	63 292 180
DES	1,33	INFO	63 468 533

Table 3: Supply chain costs in different scenarios. Data by Byrne & Heavey (2006)

As seen from Table 3, information sharing decreases total supply chain costs apart from one scenario, actual data with high capacity. On-time delivery percentages vary significantly by product, and it might be that in the NO INFO scenario Company X managed to find a better production mix, since INFO's backorder costs were higher. With more capacity at hand, actual demand and information sharing provide cost savings compared to actual demand figures alone. This shows the dependence between information sharing and accurate forecasts: they work best together. As seen from Table 3, no forecast can beat actual data, regardless of information sharing. In the original text Byrne and Heavey present demand figures for different products, and they vary significantly, resulting in sizable backorder costs. Company X could try to cooperate with its customers to come up with better, seasonally adjusted forecasts in order to cut costs for all parties and improve service levels. The table also shows, that the higher the capacity usage, the higher the potential supply chain cost savings.

Since backorder costs make up for a large portion of supply chain costs (>50%), information sharing should be beneficial. With capacity tightness of 1,05, information sharing cuts distributor backorder costs of DES forecast by approximately 10,5%. At the same time, inventory costs go up circa 2,7%. The backorder costs are almost six times higher than holding costs, resulting in a significant cost reduction. In this case then, information sharing helps meet customer demand more accurately, decreasing total costs. But since the distributors are the ones sharing information, it is expected that Company X's costs go down as well. This is the case, with backorder costs going down by approximately 7% for Company X. The relative division of supply chain costs changes, with the distributor benefiting more. But in euros Company X saves more due to its higher, especially backorder-related, costs.

The cost reduction for Company X was 3,3-6,3%, and for the distributors 5,5-9,7%; depending on product, forecast method and capacity tightness. In euros, the savings were at most 5 and 3,5 million, respectively. These figures prove the hypothesis correct that buyers tend to benefit more from information sharing. In this case however, since Company X's monetary benefit was higher, and the division of benefits was relatively fair, the outcome is clearly a win-win. This isn't always the case, hence the parties' views of what is fair may be in dispute.

Even when the cost savings are apparent, Company X's problems are not related to the lack of information sharing; they're perhaps related to the lack of using information in production planning. It isn't uncommon that companies don't know how to use information to its full advantage (Berez et. al 2016). Even with CT of 1,33, with capacity utilization correspondingly 75%, actual demand as forecast and with information sharing backorder costs account for over 54% of its supply chain costs, which is a poor result. For a CT of 1,05, the share of total costs is approximately 80%. Thus, it seems that Company X's problems are due to inability to deliver on time caused by long ordering and/or production lead times, or too optimistic shipping policy. Late deliveries cause Company X to lose business, in addition to costing money. The poor performance of Company X highlights the fact that data needs to be processed and used appropriately before it has considerable value.

Clearly then, information sharing provides costs savings. But supply chain performance was also studied, in form of OTIF (On-Time In-Full). Table 4 shows OTIF deliveries in percentages for different scenarios. Again, information sharing seems beneficial, improving Company X's on-time delivery rate.

As seen from the data, the higher the capacity usage, the worse the OTIF. Also, information sharing seems to increase stock levels. But after analyzing total inventory and backorder costs before and after information sharing, despite the grown stock, costs were from 4,6% to 7,0% lower with information sharing. The original data also provides OTIF's for selected products, and the numbers vary significantly, as do lead times. Thus, to ensure better OTIF, higher level of stock is held. The reduction of backorder costs exceeds the cost of extra inventory. SMA is the better of the two forecast methods, both in terms of OTIF and backorder and inventory costs. Hence the choice and accuracy of a forecast are very important for information sharing to be successful.

Mode CT	Info 1,05	No info 1,05	Info 1,18	No info 1,18	Info 1,33	No info 1,33
SMA OTIF	38,8 %	33,1 %	49,8 %	46,3 %	57,2 %	52,2 %
DES OTIF	38,1 %	32,2 %	49,7 %	43,3 %	56,8 %	49,7 %
SMA Stock	892	772	1198	1107	1333	1232
DES Stock	889	648	1181	1017	1325	1186

Table 4: OTIF and average stock levels in different scenarios (Byrne & Heavey 2006)

The results of the case study by Byrne and Heavey (2006) are clear. The results indicate that information sharing is beneficial, for both Company X and its distributors. It has to be noted that Company X is an industrial manufacturer, and the result might not be the same even for a company of the same industry, let alone some other industry. However, in most cases the outcome should be positive, since information sharing reduces uncertainty significantly. Assuming companies have adequate IT capabilities, there aren't many reasons why information shouldn't be shared with key partners.

4.5 DIVISION OF INFORMATION SHARING BENEFITS

In occasions where demand variability is large, suppliers tend to benefit from information sharing more than the buyers (Lee et al. 2000). Hence the buyer may not be willing to share information, because it does not necessarily gain as much, as the supplier enjoys reductions in inventory and backorder costs. Thus, the buyer may want incentives in order to share information. These incentives may include fixed fees, penalties from delayed orders and lead time reductions (Lee et al. 2000). Fixed fees are paid by the supplier to the buyer, since it's the one getting the most out of the arrangement. Penalties for late deliveries might be used by the buyer, such as in the case of GM's Saturn, which at one point started fining its suppliers by every delayed minute (Lee & Whang 1999). Lead time reductions are more complicated and require deep collaboration, since it typically requires alterations to a supplier's production. As with any other investment, the present value of process reengineering must exceed zero to be worthwhile. For suppliers to reengineer their processes, close collaboration and partnerships are required, such as in the case of Toyota using JIT and its suppliers adopting that philosophy as well.

In most cases, the buyers are the ones that benefit most from information sharing. When the supplier receives accurate, real-time information, it can respond proactively to demand variations. The buyer can then reduce its own inventory levels and cut costs, and even start a continuous replenishment program (Yao et al. 2007). A well-known success story of implementing an information sharing program is Wal-Mart's Retail Link, which enables suppliers to access real-time POS data online (Lee et al. 2000). The "peak" of information sharing is a vendor managed inventory (VMI) system, which can provide sizable cost savings in the supply chain. In this model, the buyer doesn't keep stock at all. Most of these supply chain savings are claimed by the buyer (Claassen et al. 2008).

In practice, information sharing means that information will become centralized, that is; information is located at one place and accessible by all parties. Suppliers can then use this data to optimize production and deliveries. Due to the development of information systems, companies have moved away from production site and distribution center -specific systems and changed into company-wide ones, which are no longer powered by local server farms, but rather by web hosting services (Soliman et al. 2000). Centralization can eliminate overlapping functions within an organization and some functions can even be automated.

Lee et al. (2000) note that suppliers benefit from the transparency of information sharing too. When they have accurate data from their customer, they're able to order more accurately from their suppliers. Centralized data enables supply chain -wide planning and optimization of orders and deliveries, which is beneficial for the parties involved.

Lee and Whang (2000) conclude their article by stating "- we should note that information sharing is only an enabler for better coordination and planning of the supply chain. Hence, companies must develop capabilities to utilize the shared information in an effective way." This statement emphasizes the importance of transforming data into information, so that it can be used for decision making. Information sharing itself doesn't provide cost savings, but using the information for production planning does. Next, some popular arrangements are presented, which help decrease supply chain costs even more with the help of shared information.

4.6 VALUE ADDING APPLICATIONS OF INFORMATION SHARING

Information sharing enables many levels of supply chain integration, with the intention of cost reduction and/or performance increase of supply chains. Some other closely related terms to information sharing in addition to the previously mentioned VMI include collaborative planning, forecasting and replenishment (CPFR), efficient consumer response (ECR) and quick response (QR). Also, continuous replenishment programs (CRP) are derivatives of information sharing. CPFR's joint forecasts have been shown (Yao & Dresner 2008) to reduce inventories efficiently in high autocorrelation demand alongside with VMI. ECR on the other hand, attempts to increase service levels of grocery stores. Quick response differs from the above ones, since it intends to reduce lead times, especially in manufacturing (Iyer & Bergen 1997). These models embody the strategic side of information sharing, and help companies change to more efficient practices. Due to the strategic nature, the benefits for each company vary and may be hard to assign.

Vendor-managed inventories are a part of supply chain integration and are enabled by information sharing, and popular especially among retailers. In VMI, a supplier becomes responsible for a buyer's stock, resulting in changes for both parties (Kuk 2004). Thus, the supplier is responsible for maintaining its customer's service level of certain goods. The buyer no longer orders from the supplier, nor keeps stock, instead the supplier makes replenishment decisions based on data received from the buyer (Yao & Dresner 2008). VMI offers cost savings primarily due to the traditional nature of retail purchasing: large quantities, rarely. Buying in large quantities may yield discounts, guarantees a sufficient service level and makes it easy to stay within agreed stock levels at the end of a period. This causes high holding costs for retailers and suppliers as well. The supplier's losses come from having to deliver a sizable order rarely, which triggers a policy to keep large inventory. Frequent deliveries enable continuous production, and as a result less stock is needed (Waller et al. 1999).

An article by Waller, Johnson and Davis (1999) argues that VMI is popular among companies which sell a large variety of products, e.g. the grocery market, because it is hard to cooperate deeply with each supplier. The lack of cooperation and understanding may cause suppliers to misinterpret fluctuating orders as permanently altered demand, even if the variation is seasonal, resulting in unnecessary costs for one or both parties. In VMI, the retailer provides POS (Point of Sale) and other data to the supplier and it makes its own forecasts and decisions about when to replenish the buyer's inventories. With VMI, replenishments occur at more frequent intervals, while leveraging efficient transports, such as full truckloads. More deliveries also guarantee a better service level, resulting in a reduction of stock-out costs. VMI and the information sharing it requires also reduce the risk of the bullwhip effect (Claassen et al. 2008).

According to Yao, Evers and Dresner (2007), VMI has been proven to offer cost savings but the savings aren't usually equally distributed. Since VMI is fundamentally moving the buyer's inventory to the hands of the supplier, is its expected that the buyer gains more out of the deal, as the findings of the article and many of its references show. Ordering costs are reduced for the buyer also, albeit they mostly transform into information processing and bookkeeping costs. For VMI to be mutually beneficial, the buyers should offer compensation or take more products of a supplier for sale, for example. Yao and others (2007) gave insight about consequences after VMI adoption in their article; one scenario saw the supplier's inventory increase by 34%, while the buyer's was reduced by 38%.

Kuk's (2004) analysis has shown, that smaller companies are likely to benefit more from VMI than larger ones. He and Claassen et. al (2008) point out in their articles that large companies generate vast amounts of information, which may cause problems for the IT-systems of suppliers. Also, holding costs of big companies may undercut their suppliers' ones, reducing the benefits of VMI. Based on empirical evidence it seems that most benefits related to VMI come from producing standard products, with short setup times (Kuk 2004). Companies like Honda and Toyota have moved away from VMI's, relying more on quick response deliveries and close distances to supplier's facilities (Handfield 2013). Those companies, however, are large thus having power over their suppliers and making it possible for them to take advantage of just in time deliveries, with hardly keeping any stock. In JIT, suppliers also enjoy major inventory reductions, when moving to make-to-order way of operating. VMI might then be good for smaller companies, as Kuk's article argues.

CRP, short for continuous replenishment program, is a term closely related to information sharing (Yao et al. 2007). CRP is increasing the frequency of deliveries from the supplier to the buyer. VMI can be seen as the next step after CRP, as Figure 4 below depicts. CRP isn't the same thing as JIT though, in which the buyer may dictate the time of deliveries. CRP is about rationalizing logistics mutually between a buyer and supplier. CRP doesn't require process reengineering either, as in many cases of JIT.

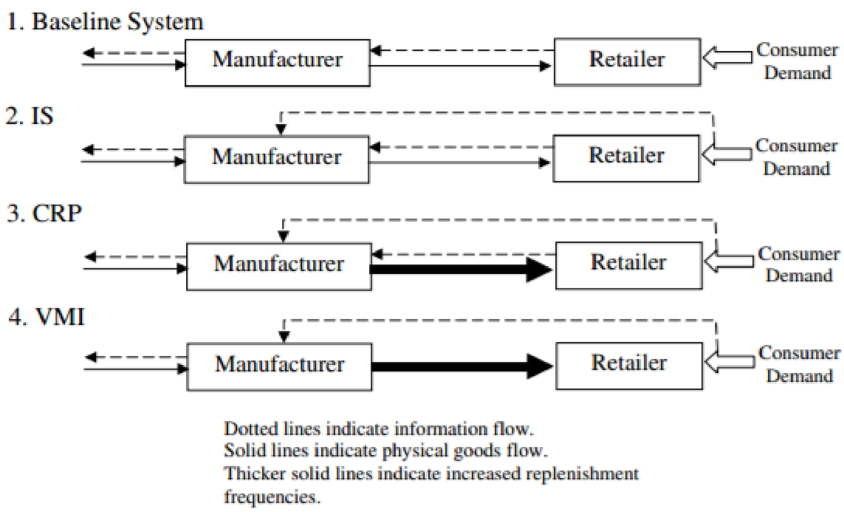


Figure 4: Differences between variations of information sharing (Yao & Dresner 2008)

Figure 4 presents the similarities and differences between different systems enabled by information sharing. In the baseline, i.e. no information sharing, system; the manufacturer only receives orders from the retailer. In an information sharing (IS) system, the retailer delivers POS and other data to the manufacturer, to increase service level. In the continuous replenishment program (CRP), the manufacturer increases the frequency of its deliveries to the retailer in addition to IS. Finally, in the vendor managed inventory (VMI) system, the retailer no longer makes any kinds of orders to the manufacturer, instead the manufacturer makes its own forecasts based on information from the retailer and decides when to supply the retailer (Yao & Dresner 2008).

This chapter covered what information sharing is, how it is executed in practice, what it enables and its role in supply chain management. The benefits of information sharing include reduced stock and increased service level. Literature has shown that all parties benefit from information sharing to some extent, although buyers tend to benefit most. Also, smaller companies may benefit more relatively, given their higher stock holding costs. The bullwhip effect was presented, a well known phenomenon in supply chains. The longer the supply chain, the stronger the bullwhip effect. Based on studies, information sharing reduces the bullwhip effect and its costs. The benefits of information sharing are also presented, especially how it changes ordering, stock and delivery policies.

A case study was used to reflect the benefits of information sharing, with scenarios with and without information sharing. A direct comparison between supply chain costs and performance was shown, along with an analysis of the results. Based on the figures of the case study and researches presented, information sharing is beneficial both in terms of supply chain costs and performance. Based on the study and papers, information sharing is most beneficial when products are standard, both demand variation and capacity usage are high and forecasts are accurate. Lastly, systems which base on information sharing were presented. Figure 4 shows the differences between the systems.

5 COMPLICATIONS OF INFORMATION SHARING

Information sharing is not risk-free. Information can be shared to improve performance and decrease costs, but the information can also be misused and exploited. Since the information shared is almost always sensitive, it getting into wrong hands is a true concern for companies. Naturally contracts and non-disclosure agreements are made, but they cannot concretely prevent the information from being misused. In this chapter the focus will be on potential information leaks and how to possibly prevent them, but unauthorized database penetrations and data theft are threats as well. Data storage is often outsourced to a third party, especially in SaaS systems, which potentially increases the risk of data theft and complicates the information sharing procedure, since the aspect of information security needs to be assessed too when evaluating the third party service provider. Also, today the geographical location of the data center where data is held needs to be considered. New regulations can prevent keeping data in another geographical area than where the data is from. For instance, the European Union has come up with the General Data Protection Regulation (GDPR), which prevents storing EU data in the U.S. from May 2018 onwards.

As mentioned in the beginning of this thesis, the fear of information exploitation is one of the major hurdles preventing companies from sharing information. Information sharing is a result of a mutual agreement, which is not accepted if there's no trust between the partners. Yet still, sensitive information can be exploited by the parties. In normal occasions, information sharing is limited to sales and stock data, but in deeper buyer-supplier relationships more sensitive data can be shared. If this data is then misused, competitors may become aware of a company's level of profitability, and exploit it. In arrangements where the distribution of benefits is not equal, hiding some information can be used to generate a more equal outcome. "Information rent" is used to describe a situation in which a party has superior information, which gives advantage and can even be used to pressure the other party (Lee & Whang 2000).

Information manipulation is a negative phenomenon related to information sharing. Quantity flexible (QF) contracts are used to counter order manipulation by buyers. When the buyer is sharing information, it may provide the supplier with overstated demand figures, in order to increase the supplier's stock. By doing this, the buyer still enjoys low stock-related costs, but it has a buffer stock in the supplier's end. This may cause the supplier to understate demand information, and thus the arrangement isn't optimal. QF contracts have upper and lower levels, and the supplier must always be able to deliver the highest quantity. However, the buyer also has to purchase the lowest quantity, which decreases the willingness to overstate shared information (Lee & Whang 2000, Tsay & Lovejoy 1999).

Lee and Whang (2000) have presented some other dangers of information sharing. Not all companies have the necessary IT capabilities to share or make use of information. Also, information itself has little value and it needs processing to have an impact. Hence, analytical skills are needed, too. Lee and Whang also mention, that if data isn't timely, problems may occur. Say, if customers provide a supplier with POS data monthly, but the exact dates vary, production planning becomes difficult. On the other hand, one could question the value of monthly information sharing, since it doesn't differ much from normal ordering. In addition, companies might be less willing to share information if the other party belongs to the same corporate group as a competitor.

6 CONCLUSIONS

The research question of this thesis was: is information sharing beneficial? Based on academic literature and a case study the answer to that question is yes, both in terms of costs and supply chain performance. The role of ERP systems as enablers of information sharing was emphasized, alongside with SaaS systems in an attempt to reduce ERP costs. Information sharing is a link between ERP systems and SCM, allowing companies to widen their view from internal processes to external as well. Due to globalization and complex supply chains, a product's value is created by multiple parties. Therefore, manufacturers should cooperate with their supply chain partners, and information sharing is one way to do that. Information sharing also has an operational side. Suppliers can use data from their customers to plan production and thus better match demand, reducing costs for all parties. For instance, sharing on-time forecasts enables steady production, frequent deliveries and thus lower stocks for suppliers and buyers. Indicative supply chain cost reductions range from 3,3% to 9,7% based on empirical evidence. The benefits aren't always equally distributed, though, and the buyers usually benefit more. Arrangements can be made to equalize division of benefits, but since both parties enjoy cost reductions, information sharing is rational even though one party benefits more.

What drives the potential benefits most are accurate forecasts, high capacity usage, standard products, high demand variation and long lead times. Cost reductions of information sharing can be divided into two: supply chain and company-specific. Reduction of the magnitude of the bullwhip effect helps reduce supply chain -wide costs, and optimized stocks help reduce the costs for individual companies, for instance. Extra revenues may also emerge due to increased service levels. It appears that simple information sharing is typical in B2B trade, whereas advanced practices such as VMI are popular among retailers.

As pointed out in this thesis, information itself has little value if it's not processed or utilized appropriately. Likewise, data exchange can be used as a basis for more efficient systems. These include VMI, CRP and JIT. The case study by Byrne and Heavey was one of the only studies that focused on information sharing alone, i.e. the focus of this thesis, instead of some of its derivatives, which indicates that also companies take information sharing further than just information exchange. Similarly, the focus here was on the effects of information sharing on supply chain costs and performance, i.e. the operational side. Information shared could be used strategically, for instance, in product development, customer profiling and market research, but these topics were beyond the scope of this thesis.

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Pictures

Picture 1: Slide 51, https://www.slideshare.net/ansuman123/1-sap-forretailoverview 27.4.2017